tubes 330, 335 through which extend a pair of respective push rods 340,345. The push rods 340,345 extend between a pair of respective rocker arms 350,355 and a pair of cams 360, 365 (see Fig. 8) within the crankcase 110, as discussed further below.

[0039] Turning to Figs. 5 and 6, the engine 100 is shown with the top 290 of the crankcase 110 removed from a bottom 370 of the crankcase 110 to reveal an interior 380 of the crankcase. Additionally in Figs. 5 and 6, the engine 100 is shown in cut-away to exclude portions of the engine that extend beyond the cylinder 160 such as the cylinder head 170. With respect to Fig. 6, the top 290 of the crankcase 110 is shown above the bottom 370 of the crankcase in an exploded view. In this embodiment, the bottom 370 includes not only a floor 390 of the crankcase, but also all four side walls 400 of the crankcase, while the top 290 only acts as the roof of the crankcase. The top 290 and bottom 370 are manufactured as two separate pieces such that, in order to open the crankcase 110, one physically removes the top from the bottom. Also, as shown in Fig. 5, the pair of gears 320, 325 within the crankcase 110 form part of respective camshafts 410,415 (see also Fig. 8) which in turn are supported by the bottom 370 of the crankcase 110. As discussed further with respect to Figs. 9-12, the camshaft 410 in particular is supported by a pump 412, which in turn is supported by the bottom 370 of the crankcase 110. Because of its location along the bottom 370 of the crankcase 110, which acts as an oil reservoir, the pump 412 receives oil collected within the bottom 370 of the crankcase 110. The pump 412 further is actuated due to the rotation of the camshaft 410. A lower crankshaft bearing 540 for supporting the crankshaft 220 is additionally shown in Fig. 5 along the floor 390.

the camshafts 410,415 are identical to allow for even easier mass-production of the camshafts.

[0042] Additionally, respective cam follower arms 470,475 that are rotatably mounted to the crankcase 110 extend to rest upon the respective cams 360,365. The respective push rods 340,345 in turn rest upon the respective cam follower arms 470,475. As the cams 360,365 rotate, the push rods 340,345 are temporarily forced outward away from the crankcase 110 by the cam follower arms 470,475, which slidingly interface the rotating cams. This causes the rocker arms 350,355 to rock or rotate, and consequently causes the respective valves 240 and 250 to open toward the crankcase 110. As the cams 360,365 continue to rotate, however, the push rods 340,345 are allowed by the cam follower arms 470,475 to return inward to their original positions.

[0043] A pair of springs 480,490 positioned between the cylinder head 170 and the rocker arms 350,355 provide force tending to rock the rocker arms in directions tending to close the valves 240,250, respectively. Further as a result of this forcing action of the springs 480,490 upon the rocker arms 350,355, the push rods 340,345 are forced back to their original positions. The valve trains 460,461 are designed to have appropriate rocker ratios and masses to control contact stress levels with respect to the cams 360,365. Fig. 7 additionally shows that the components of the respective valve trains 460,461 are positioned on opposite sides of the cylinder 160 and cylinder head 170, thus exposing a valve bridge area 610.

[0044] In the present embodiment, the engine 100 is a vertical shaft engine capable of outputting 15-20 horsepower for implementation in a variety of consumer lawn and garden machinery such as lawn mowers. In alternate embodiments, the engine 100 can also be

[0069] The first and second grooves 930,940 of each flange 850 are coupled to one another at the location where the inner and outer edges 945,965 of the flange meet. Consequently, when the respective flanges 850 are positioned onto the respective main segments 810, such that the outer edges 965 abut the main segments 810 and the inner edges 945 abut the outer sides 865 of the respective crank arms 830, respective passages 935 are formed by the respective sets of grooves 930,940 (as shown best in Fig. 20). Lubricant such as oil 970 is therefore able to flow through the passages 935 between the exterior portions 815 of the main segments 810 and the oil galley 920. Lubricant is able to arrive at the passages 935 when provided by way of the crank main bearings 570,540 to the exterior portions 815 of the main segments (which correspond to portions 700,710 shown in Fig. 18), since some of the lubricant that is provided to those portions 815 proceeds into the passages 935.

[0070] As shown in Fig. 20, in the present embodiment, an additional channel 950 connecting the oil galley 920 to the exterior of the crank pin 820 is also provided. The additional channel 950 allows oil to flow also between the oil galley 920 and the outer surface 925 (or crank pin bearing) of the crank pin 820, thereby allowing for lubrication of the interface between the crank pin and the connecting rod 420. Although in Fig. 20, the additional channel 950 is shown to proceed outward from the oil galley 920 toward the portion of the outer surface 925 that is farthest from the central axis 840, in alternate embodiments the channel will proceed toward a portion of the outer surface that is intermediate the portions that are farthest from and closest to the central axis 840, so that oil flow to the outer surface 925 is not impeded or overly enhanced due

implemented as a horizontal shaft engine, be designed to output greater or lesser amounts of power, and/or be implemented in a variety of other types of machines, e.g., snow-blowers. Further, in alternate embodiments, the particular arrangement of parts within the engine 100 can vary from those shown and discussed above. For example, in one alternate embodiment, the cams 360,365 could be located above the gears 320,325 rather than underneath the gears.

[0045] Referring still to Fig. 8, the camshafts 410,415 have respective internal channels 500,505, through which oil or other lubricant can be communicated. The internal channel 500 in particular communicates oil upward from the pump 412 to the gear 320, while the internal channel 505 communicates oil downward from the gear 325 to the base of the camshaft 415, where that camshaft rests upon the floor 390 of the crankcase 110. As discussed more fully with reference to Fig. 16, the internal channels 500,505 form a portion of an overall oil circuit of the engine 100.

[0046] Turning to Figs. 9 and 10, a top view and an elevation view (as viewed from the side wall 400 opposite the cylinder 160) of the bottom 370 of the crankcase 110 are provided. Fig. 9 in particular shows the pump 412 supported by the floor 390 of the crankcase. Further referring to Figs. 11-14, the pump 412 is shown in greater detail. As shown particularly with respect to Figs. 11-12, which are sectional views of the pump 412 taken along lines 11-11 and 12-12 of Fig. 10, respectively, the pump in a preferred embodiment is a gerotor pump (or, alternatively, a crescent pump) of conventional design having an inner gear 510 positioned within an outer ring gear 515 having gear teeth along its inner circumference.

of holes in those bearings). Upper and lower bores 708 and 718 drilled within the crankshaft 220 respectively extend from the respective grooves 712 of the upper and lower shaft bearing portions 700,710 through upper and lower crankarms 720 and 730, respectively, to an internal channel 724 extending within a crankpin 701 of the crankshaft generally parallel to a central axis 726 of the crankshaft 220.

[0058] As shown, the upper and lower bores 708,718 extend at oblique angles between the grooves 712 and the crankpin 701, relative to the central axis 726. By drilling the bores 708,718 in this manner, each of the bores 708,718 can respectively be formed simply by drilling a single straight hole. Nevertheless, in the embodiment shown, three other bores must be drilled in order to communicate oil to three different locations along the crankshaft 220. First, the crankpin 701 includes a first additional bore 715 that connects the internal channel 724 to an outer surface of the crankpin that forms a crankpin bearing 702. Thus, oil provided to the internal channel 724 by way of the upper and lower bores 708,718 in turn is communicated to the outside of the crankpin 701 to provide lubrication to the crankpin bearing 702.

[0059] Also as shown in Fig. 18, the crankshaft 220 includes first and second eccentric bearings 704 and 706, respectively, which support the one or more counterbalances 440. The first eccentric bearing 704 specifically is positioned along the crankshaft 220 between the upper crankarm 720 and the upper shaft bearing portion 700, while the second eccentric bearing 706 is positioned between the lower crankarm 730 and the lower shaft bearing portion 710. In order to provide oil to the first and second eccentric bearings 704 and 706, second and third additional bores 722 and 732,